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MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Technical Performance Measurement (TPM) Plan

November 1997
(revised)

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Earth Science Data and Information System (ESDIS)
Level 1 Product Generation System (LPGS) Technical Performance Measurement (TPM) Plan

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Abstract

The Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) will be operated within the Earth Observing System (EOS) Ground System (EGS). This will provide Landsat 7 Enhanced Thematic Mapper Plus (ETM+) systematically corrected digital images for distribution to the Earth Observing System (EOS) Data and Information System (EOSDIS) Core System (ECS) customers. The Technical Performance Measurement (TPM) plan presented in this document identifies critical LPGS technical performance parameters; documents their measurements, estimates, and projections; and provides a methodology for tracking and reporting during the development life cycle.

***Keywords**: Earth Observing System (EOS) Data and Information System (EOSDIS) Core System (ECS), Earth Science Data and Information System (ESDIS), Level 1 Product Generation System (LPGS), Technical Performance Measurement (TPM)*

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Section 1. Introduction

1.1 Purpose

This Technical Performance Measurement (TPM) plan identifies critical Level 1 Product Generation System (LPGS) technical performance parameters; documents their measurements, estimates, and projections; and provides a methodology for tracking and reporting during the development life cycle. TPM is a system engineering discipline related to risk management that allows detection of system or system element variances early enough in the life cycle to apply, in a cost-effective manner, corrective actions when out-of-specification conditions occur or are projected.

1.2 Scope

TPM assesses critical technical performance parameters at the system level as well as allocated or derived requirements at the subsystem level. TPM assessment is phased in accordance with the release and associated mission functionality given in the Image Assessment System (IAS) Release Implementation Plan (Reference 8) and the LPGS Release Implementation Plan (Reference 9). The IAS Implementation Plan (Reference 8) is used as a reference because significant reuse of IAS developed software is planned for the LPGS.

1.3 Applicable Documents

The information in the following documents was used to develop this Technical Performance Measurement Plan.

1. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), 510-FPD/0196, *Level 1 Product Generation System (LPGS) Functional and Performance Requirements Specification*, February 1997
2. —, 510-3OCD/0296 (CSC 10034093), *Level 1 Product Generation System (LPGS) Operations Concept*, February 1997
3. —, 510-4SDS/0196 (CSC 10034686), *Level 1 Product Generation System (LPGS) System Design Specification*, March 1997
4. —, *Landsat 7 Image Assessment System (IAS) System Design Specification*, February 1997
5. Computer Sciences Corporation (CSC), SEAS System Development Methodology (SSDM) Standard 2102, *Technical Performance Measurement*, August 1994
6. —, SSDM Section 5, *Systems Engineering*, July 1996
7. NASA, GSFC, *Level 1 Product Generation System (LPGS) Performance and Sizing Estimates*, June 1997

8. —, 514-4ICD/0197 (CSC 10037996), *Landsat 7 Image Assessment System (IAS) Release Implementation Plan* (Review), August 1997

9. —, 510-2RIP/0197 (CSC 10037828, *Level 1 Product Generation System (LPGS) Release Implementation Plan* (Review), August 1997

1.4 Definitions

The following terms, as defined in this section, are commonly used throughout this document to describe LPGS processing:

Level 0R (L0R) digital image—Spatially reformatted, demultiplexed, and unrectified subinterval data.

Level 0R (L0R) product¾The L0R digital image plus radiometric calibration, attitude, and ephemeris data, consisting of the following files:

- L0R digital image
- Internal calibrator (IC) data¾Calibration data file containing all the calibration data received on a major frame basis for a given subinterval
- Mirror scan correction data (MSCD)¾The scan direction and error information for a given subinterval
- Payload correction data (PCD)¾Information on spacecraft attitude and ephemeris, including quality indicators for each subinterval
- Metadata¾Descriptive information about the L1 digital image, names of appended files associated with the image, and quality and accounting information
- Calibration parameter file (CPF)¾A formatted file containing gains, biases, and offsets for the instrument and detectors

Level 1R (L1R) digital image—Radiometrically corrected but not geometrically resampled. Image size can be from 0.5 to 3 Worldwide Reference System (WRS) scene equivalents. Can be WRS-based or have a floating scene center, but is restricted to one orbital path and must be generated from the same Level 0 acquisition interval.

Level 1G (L1G) digital image—Radiometrically corrected and resampled for geometric correction and registration to geographic map projections. Can be WRS-based or have a floating scene center, but is restricted to one orbital path and must be generated from the same Level 0 acquisition interval.

Level 1R (L1R) product—L1 product, packaged by LPGS and distributed by the Earth Observing System (EOS) Data and Information System (EOSDIS) Core System (ECS) to the customer, includes for all requested bands: L1R image data, metadata including processing quality information, IC data file, CPF, combined PCD file, combined MSCD file, and geolocation table in hierarchical data format (HDF).

Level 1G (L1G) product—L1 product, packaged by LPGS and distributed by the ECS to the customer, includes for all requested bands: Fast Argonne System for Transport (FAST) or geographic tag(ged) image file format (GeoTIFF) L1G image and associated data accommodated by the format; HDF format L1G image, metadata, CPF, and geolocation table.

Production quality assessment—Ancillary information collected and generated during L1 processing; provides information on the certainty with which corrections were made to images; nominally appended as a file to the L1 product.

Interval—The time duration between the start and stop of an imaging operation (observation) of the Landsat 7 enhanced thematic mapper plus (ETM+) instrument.

Subinterval—Segment of time corresponding to a portion of an observation within a single Landsat 7 contact period.

Worldwide Reference System (WRS) scene—Digital image that covers an area equivalent to one of the 57,784 scene centers (233 paths x 248 rows areas) defined by the WRS structure.

Section 2. System Overview

2.1 LPGS Overview

The LPGS is a source of ETM+ Level 1 (L1) data within the Earth Science Data and Information System (ESDIS) Ground System (EGS). The EGS is a collection of ground support elements for the EOS and includes EOSDIS, institutional support elements, affiliated and international partner data centers, international partner instrument control and operations centers, and other sources of data. The LPGS is located at the Earth Resources Observation System (EROS) Data Center (EDC) Distributed Active Archive Center (DAAC) and provides ETM+ L1 digital image generation and transfer services on a demand basis. The LPGS receives L1 digital image generation requests and distributes generated L1 digital images to customers through the ECS at the EDC DAAC nominally on a first in-first out (FIFO) basis.

The LPGS produces L1 data images in electronic format corresponding to a WRS scene, floating scene center, or partial ETM+ subintervals of up to three WRS scene equivalents based on customer requests. The LPGS can produce a daily volume equivalent to at least 25 WRS scenes of L1 radiometrically corrected and geometrically corrected images in any combination. The LPGS can create digital images projected to different coordinate reference systems, for any combination of the eight spectral channels collected by the ETM+ instrument, or in different output formats according to other options specified in the customer's request. The L0R data are requested from the ECS, and appended calibration parameter, PCD, and MSCD files are applied by the LPGS in producing L1 digital images.

The digital images created by the LPGS are provided, along with quality information (metadata), associated calibration parameter file, PCD, MSCD, and calibration data to the ECS, which distributes the entire L1 product to the customer

2.2 Performance Requirements

The following are the performance requirements for the LPGS hardware, software, and workload scenarios:

Requirement 4.1.1—The LPGS shall be capable of processing a volume of data equivalent to 28 (accounts for 10 percent LPGS internal reprocessing) standard L0R WRS scenes to Level 1 digital images each day.

Requirement 4.1.4—The LPGS shall provide at least 110 percent of the processing throughput capability required to satisfy the worst case processor loading.

Requirement 4.1.5—The LPGS shall provide at least 125 percent of the random access memory capacity required to satisfy the worst case memory loading.

Requirement 4.1.6—The LPGS shall provide at least 125 percent of the peripheral storage capacity required to satisfy the worst case peripheral storage loading.

Requirement 4.2.1—The LPGS shall be able to ingest from ECS a data volume equivalent to three WRS scenes worth of standard L0R data for each Level 1 digital image request.

Requirement 4.2.2—The LPGS shall have the capability to support the transfer to ECS of the equivalent of a minimum of 25 WRS sized Level 1 digital images per day.

Requirement 4.2.3—The LPGS-ECS interface shall provide the capability to transfer to the ECS at least 33 gigabytes (GB) of Level 1 output files per day.

Requirement 4.3.1—The LPGS shall provide an operational availability of .96.

Requirement 4.3.2—The LPGS shall support a mean time to restore (MTTR) capability of 4 hours.

2.3 Hardware Configuration

The LPGS hardware configuration is shown in Figure 2-1.

A stripped-down version of the hardware configuration is shown in Figure 2-2. Only the Level 1 processing hardware configuration item (HWCI) and quality assessment (QA)/anomaly analysis (AA) HWCI are considered here. The L1 processing HWCI is for the L1 product generation and storage. It is assumed that the visual assessment of data quality for the automatic QA will be done on the workstation in this HWCI. For the non-nominal processing (AA), processing of data will be done on the L1 processing HWCI, but the manual analysis and visual assessment of the images (for both benchmark work order and diagnostic work order) will be done on the QA/AA HWCI.

2.4 Process Flow

The process flow for processing L1 products from ingest to ECS notification and product transfer is shown in Figure 2-3. The major functions for each process are described as follows:

- Ingest data
  - Retrieve L0R product to the input directory
- L1R processing
  - 0R radiometric characterization
  - 0R correction
  - Corrected 0R (0Rc) radiometric characterization/calibration
  - 1R correction
  - 1R radiometric characterization/correction
  - Quality assurance of L1R image

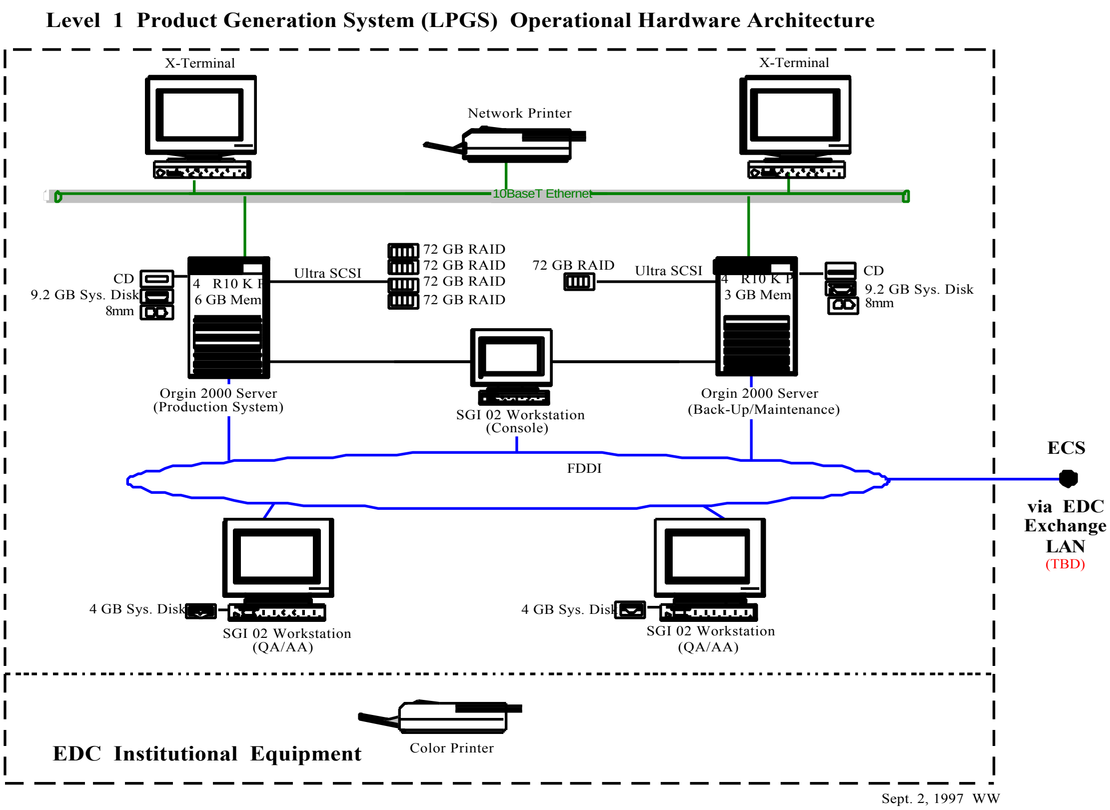

Figure 2-1. LPGS Hardware Configuration

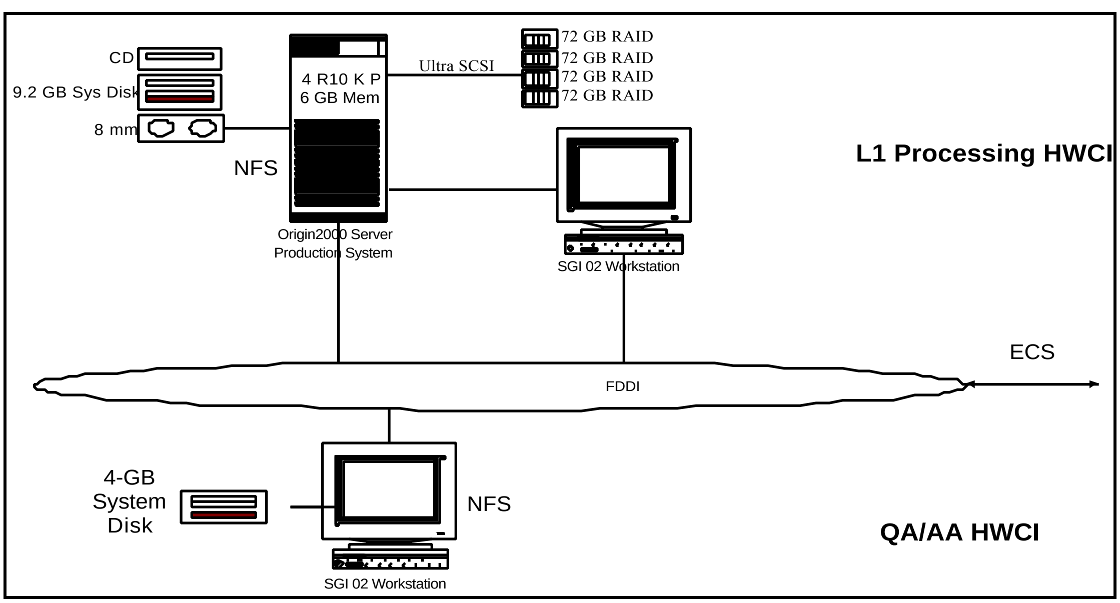

Figure 2-2. Simplified LPGS Hardware Configuration

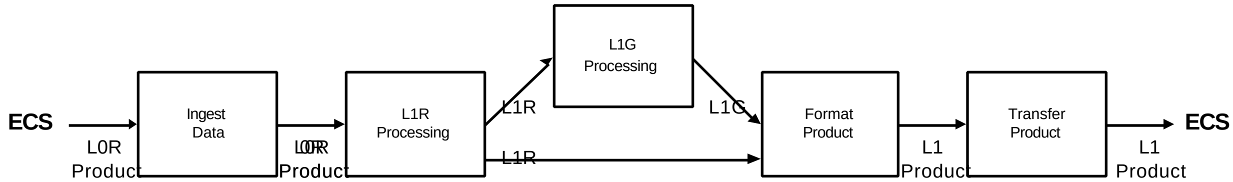

Figure 2-3. LPGS Process Flow

- L1G processing
  - Create extended image
  - Resample
  - Quality assurance of L1G image
- Format product
  - Convert L1 product into appropriate format
  - Package L1 product
  - Move L1 product to the output directory
  - Quality assurance of L1 final image
- Transfer product
  - Notify ECS of L1 product availability
  - Retrieval of L1 product from the LPGS output directory (ECS performs)

2.5 Mapping of Processes/Functions to HWCI

In the LPGS, two operational scenarios are considered: the nominal processing and the non-nominal processing (anomaly analysis). The nominal processing processes a work order from ingest through product transfer following the process flow shown in Figure 2-3. The non-nominal processing assumes processing of up to three different work orders: benchmark work order, diagnostic processing work order, and reprocessing work order. Benchmark, diagnostic, and reprocessing each require resources at the same levels as the L1R processing, L1G processing, and product formatting portions of the nominal processing. However, quality assurance will be performed on a workstation of the QA/AA HWCI and will require transferring a significant amount of data through the fiber-optic data distribution interface (FDDI).

Table 2-1 shows the mapping between the processes/functions identified in Section 2.4 and the HWCIs identified in Section 2.3 for these two scenarios.

Table 2-1. Mapping of Processes/Functions to HWCIs

		Non-Nominal Processing		
Process/Function	**Nominal Processing**	**Benchmark Work Order**	**Diagnostic Work Order**	**Reprocessing Work Order**
Ingest Data				
Retrieve L0R product to the input directory	L1 Proc HWCI via FDDI	N/A	N/A	N/A
L1R Processing				
0R radiometric characterization	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
0R correction	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
0Rc radiometric characterization/ calibration	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
1R correction	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
1R radiometric characterization/ correction	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
Quality assurance of L1R image	L1 Proc HWCI	QA/AA HWCI	QA/AA HWCI	L1 Proc HWCI
L1G Processing				
Create extended image	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
Resample	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
Quality assurance of L1G image	L1 Proc HWCI	QA/AA HWCI	QA/AA HWCI	L1 Proc HWCI
Format Product				
Convert L1 product into appropriate format	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
Package L1 product	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
Move L1 product to the output directory	L1 Proc HWCI	L1 Proc HWCI	See note	L1 Proc HWCI
Quality assurance of the L1 final image	L1 Proc HWCI	QA/AA HWCI	QA/AA HWCI	L1 Proc HWCI
Transfer Product				
Notify ECS of L1 product availability	L1 Proc HWCI via FDDI	N/A	N/A	L1 Proc HWCI via FDDI
Retrieve L1 product from the output directory by ECS.	L1 Proc HWCI via FDDI	N/A	N/A	L1 Proc HWCI via FDDI

NOTE: For the diagnostic processing work order, processing of data will be done on the L1 Processing HWCI, but the results will be displayed and analyzed on the QA/AA HWCI.

Section 3. Technical Performance Measurement Planning

SSDM Standard 2102 Technical Performance Measurement (Reference 5) is used as a general guide for implementing the technical performance measurement on the LPGS. The technical performance measurement planning consists of the following steps:

- Identifying critical technical performance parameters
- Indicating how the critical technical performance parameters are measured and evaluated
- Establishing the process for triggering corrective actions when out-of-specification conditions occur
- Developing corrective action plans and gathering additional measurements when out-of-specification conditions occur
- Determining required reports and reporting procedures
- Establishing the events/milestones where measured performance is reported

3.1 Identification of Critical Technical Performance Parameters

Technical performance parameters are selected on the basis of meeting critical performance requirements specified in the Functional and Performance Requirements Specification (F&PRS) (Reference 1). Critical technical performance parameters are selected and prioritized according to the system release and its associated set of system requirements. Technical performance parameters are also selected on the basis of criticality.

The LPGS will reuse a significant portion of the software developed by the IAS. In particular, the radiometric processing subsystem (RPS) and the geometric processing subsystem (GPS) are considered as black boxes by the LPGS implementation team. These subsystems will be integrated and tested by the IAS first. Therefore, the IAS Release Implementation Plan will also be considered in selecting the LPGS technical performance parameters and their values.

IAS Release 1 will include most of the LPGS functionality including the radiometric processing and the geometric processing with the exception of the memory effect, coherent noise, and scan-correlated shift characterization and correction. The memory effect, coherent noise, and scan-correlated shift characterization and correction for the radiometric processing will be supported in IAS Release 2.

Both IAS Release 1 and Release 2 are scheduled before any LPGS releases. Attempts will be made to measure and evaluate some technical performance parameters by using the IAS releases on the noninterference basis. However, because of the tight schedule of the IAS development and resources, there is no guarantee that this can be reasonably accomplished.

3.1.1 Technical Performance Parameters

The only critical technical performance parameter directly identified in the F&PRS is the throughput. The LPGS has the requirements to support retrieving, processing, and transferring 25 WRS scenes per day as well as to support reprocessing of three WRS scenes per day. To achieve the throughput capability, various parameters related to resource utilization need to be tracked. The following parameters which have direct effects on the throughput will be measured and tracked:

- Central processing unit (CPU) time
- Disk input/output (I/O)
- FDDI bandwidth

Table 3-1 shows the critical technical performance parameters for the major LPGS functions. Visual assessment is shown separately because it is optional and mainly affects 02 workstations.

Table 3-1. Critical Technical Performance Parameters

Parameters	Ingest Data	L1R Process	L1G Process	Format Product	Transfer Product	Visual Assessment
Throughput	X	X	X	X	X	X
Origin 2000 CPU time		X	X	X		
RAID disk I/O	X	X	X	X	X	X
FDDI bandwidth	X	X	X	X	X	X
Origin 2000 memory usage	X	X	X	X	X	
Workstation 02 CPU time						X
Workstation 02 memory usage						X

3.1.2 Technical Performance Parameter Measurement Sensitivity

Sensitivities to other parameters must be considered when generating technical performance parameter measurements. In particular, measurements will be taken to determine sensitivity of L0R product size (one-half scene, one scene, and three scenes) and grid cell size used in the geometric processing. Additional measurements planned to assess performance sensitivities include the application of the memory effect correction on the overall performance.

3.2 Parameter Measurement and Assessment

Parameter values are obtained by analysis or measurements during normal development activities. Before hardware/software availability, parameter values are estimated through engineering analysis and modeling. As hardware and software builds are completed, the actual parameter values are obtained through measurement and/or tests. A performance model was developed for the LPGS. Values estimated from the model will be used initially. The results of actual tests of as-built system components, subsystems, and complete systems will be used when they are available. The performance model will also be calibrated when the actual tested parameter values become available.

Estimated and actual values will be plotted against a planned parameter profile within a tolerance band. The new current estimate for the end product will be derived based on the actual demonstrated value and the changes to the parameter value that can be achieved within the remaining cost and schedule baseline. Upper and lower tolerance bands define the region within which requirements can reasonably be expected to be achieved within cost and schedule constraints. Actual measurements falling outside of this region will signal the need for investigation and/or corrective action. The tolerance bands should converge over time to the parameter value or range of values required. The bands should be broad in the beginning of the development effort when less is known about the system and the individual performance parameters. This will provide more flexibility in achieving the planned values without causing unnecessary management intervention. As the development effort matures, the bands should narrow so that smaller variances from the planned values will initiate management awareness and corrective action.

3.2.1 Nominal Processing

3.2.1.1 Throughput

3.2.1.1.1 Service Time

The results from the performance analysis have shown that the service time for processing one WRS scene of data is about 96.61 minutes, which includes 87.42 minutes of CPU time and 9.19 minutes of I/O (disk and FDDI) time. The service time does not include data transfer time between LPGS and ECS. The results from the system performance model are summarized in Table 3-2.

Table 3-2. System Performance Model Results

Time in Minutes	Model/Benchmark Results
Percentage of CPU utilization (28 WRS scenes per day)	42.50%
L1R processing CPU time per scene	52.19 minutes
L1G processing CPU time per scene	33.27 minutes
Ingest/product format/product transfer CPU time per scene	1.96 minutes
FDDI data transfer time per scene	3.77 minutes
Disk I/O time per scene	5.42 minutes
Total service time per scene	96.61 minutes
Elapsed time for processing four scenes on four processors	102 minutes
Percentage of system utilized for 28 scenes a day	49.6%

The baseline LPGS configuration has four processors. The current LPGS software design reuses the software from the IAS for both radiometric processing and geometric processing. This software can perform parallel processing within a band for the geometric processing but only sequential processing of all bands for the radiometric processing. To maximize the utilization of the available processors, at least four work orders will be processed simultaneously, one on each processor.

3.2.1.1.2 Elapsed Time

The elapsed time (wall clock time or end-to-end response time) for a job varies significantly, depending on what other jobs are running on the system. The minimum elapsed time assumes nothing else is running on the system and can be estimated from the service time. With a single processor, the minimum elapsed time for processing one WRS scene of data is equal to the total service time, 96.91 minutes. With four work orders of one WRS scene each being processed on four processors simultaneously, it will take more than 96.61 minutes to process four scenes. The time it takes to nominally process four scenes using four CPUs is estimated at about 102 minutes based on the probability of the disk being busy serving other product requests. It is assumed that the contention on the FDDI does not have effects on the processing time because the FDDI data transfer occurs prior to and after processing. Therefore, to process 28 WRS scenes in a 24-hour period, the overall system will be 49.6 percent [(102/4)*28/24/60] utilized. (overall system utilization = (elapsed time to process 4 scenes/4)*(28 scenes per day)/24 hours/60 minutes). The elapsed time and percent system utilization based on the model results are also shown in Table 3-2. The elapsed time and percent system utilization based on the model results are also shown in Table 3-2.

3.2.1.1.3 Throughput TPM

The throughput TPM is measured in terms of the overall system utilization for handling the required daily workload of 28 WRS scenes. Table 3-3 presents the target values for the overall system utilization at various milestones. The utilization is calculated by setting the target values for CPU utilization and tolerance factors for less critical parameters such as the CPU time for ingest, product format, and product transfer, FDDI data transfer time, and disk I/O time. These less critical parameters only contribute a small percentage of the total service time. Therefore, a larger tolerance factor can be used. The tolerance factor is also assigned to the geometric processing because the benchmark result is available for the geometric processing. The tolerance factors selected are also shown in Table 3-3. All tolerance factors are constants except those for the radiometric processing, which are derived based on other information in the table. It is expected that the planned values at the completion of LPGS Release 2 will be close to the results estimated from the performance model except the geometric processing, which is expected to have some improvement from the current benchmark result.

The total service time is calculated from the tolerance factors and the model results from Table 3-2. The average elapsed time is estimated based on the total service time and the assumption that I/O contention occurs 50 percent of time. The overall system utilization is then calculated.

This allows very little resources for non-nominal processing (AA) initially, but there should be enough resources at the completion of LPGS Release 2.

Table 3-3. Percentage of System Utilization and Tolerance Factors

System Utilization/ Tolerance Factor	LPGS Release 1		LPGS Release 2	
	Upper Tolerance Band	Planned Value	Upper Tolerance Band	Planned Value
Target CPU utilization (28 WRS scenes)	65.00%	50.00%	50.00%	40.88%
Tolerance factor with respect to the current model results				
L1R processing CPU time	165%	128%	126%	100%
L1G processing CPU time	125%	100%	100%	90%
Ingest/product format/product transfer CPU time	300%	150%	200%	100%
FDDI data transfer time	250%	150%	150%	100%
Disk I/O time	250%	150%	150%	100%
Total service time per scene	156.69 min.	116.64 min.	116.64 min.	93.28 min.
Elapsed time for processing four scenes on four processors	169 min.	124 min.	124 min.	99 min.
Percent system utilization for 28 scenes per day	82.2%	60.3%	60.3%	48.2%

The throughput TPM is shown in Figure 3-1. The corresponding service time for processing one WRS scene is shown in Figure 3-2.

3.2.1.2 CPU Time

Both radiometric processing and geometric processing require extensive processing. Therefore, the CPU time is a very critical technical performance parameter.

The upper tolerance band and the planned profile of the CPU time are derived from Table 3-3. Figure 3-3 shows TPM for the CPU time for processing one WRS scene at various milestones. The corresponding CPU utilization for a daily workload of processing 28 WRS scenes is shown in Figure 3-4. The lower tolerance band is established with the assumption that the CPU is only 30 percent utilized. This implies that three CPUs might be sufficient to support the daily workload.

The CPU time consists of several components: geometric processing, radiometric processing, data ingest, product formatting, and product transfer. Data ingest, product formatting, and product transfer do not require a lot of processing.

For geometric processing, the benchmark result is currently available. This data will be used as the initial value (33.27 minutes) for the planned parameter. It is expected that a 10-percent improvement in the CPU time can be achieved for the end product through code optimization and performance tuning.

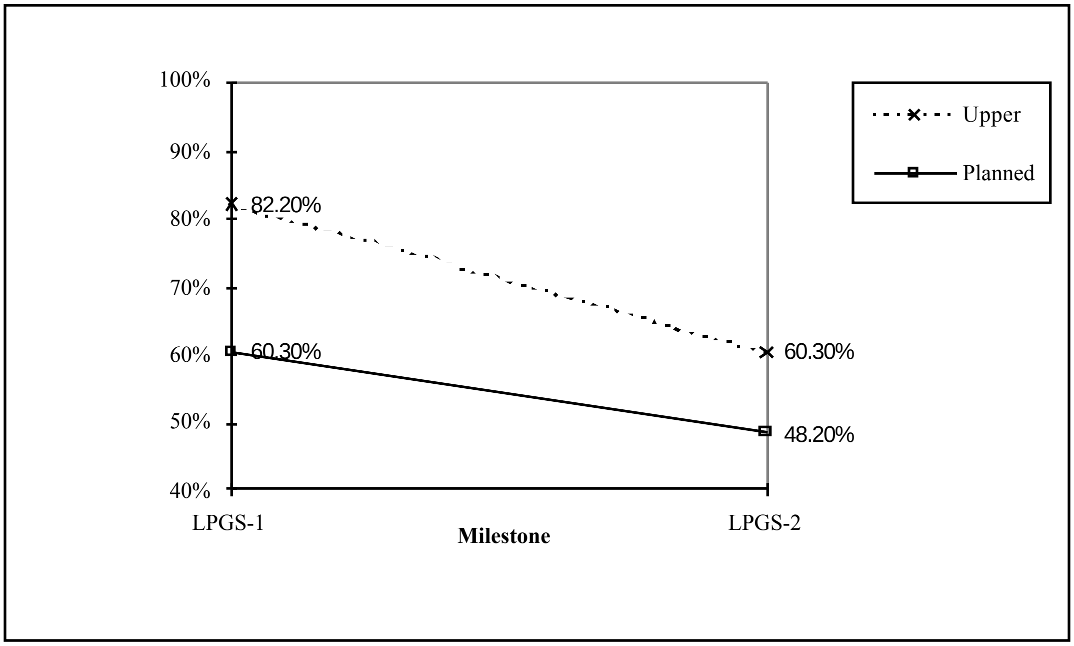

Figure 3-1. Throughput TPM for Nominal Processing (System Utilization)

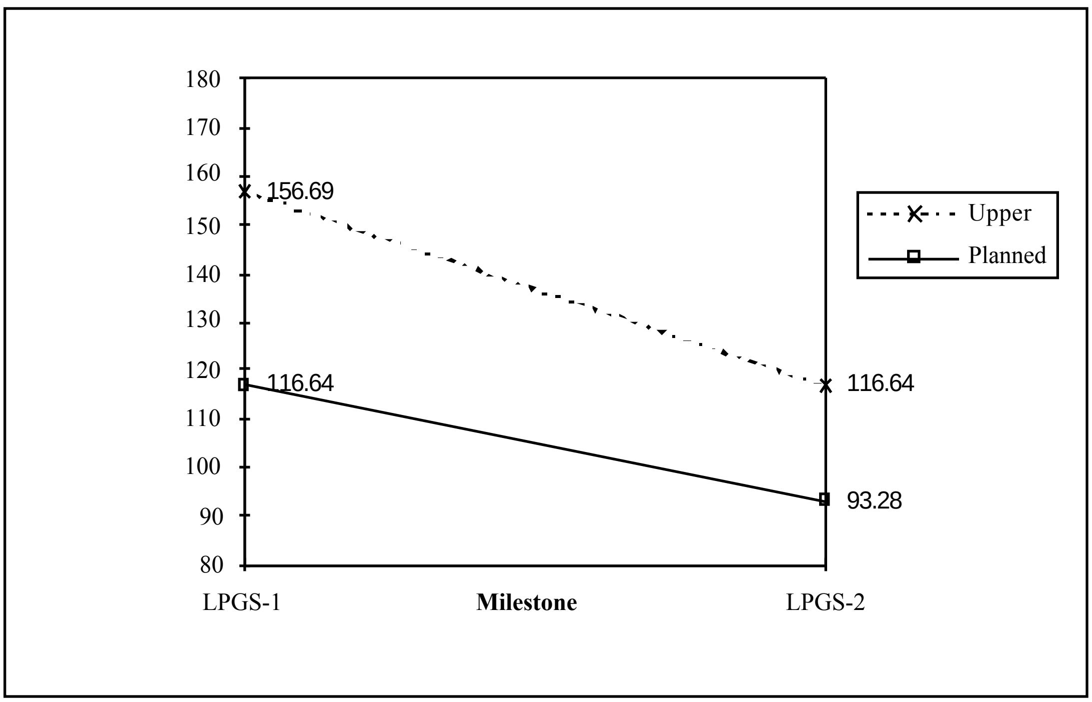

Figure 3-2. Throughput TPM for Nominal Processing (Total Service Time for One WRS Scene)

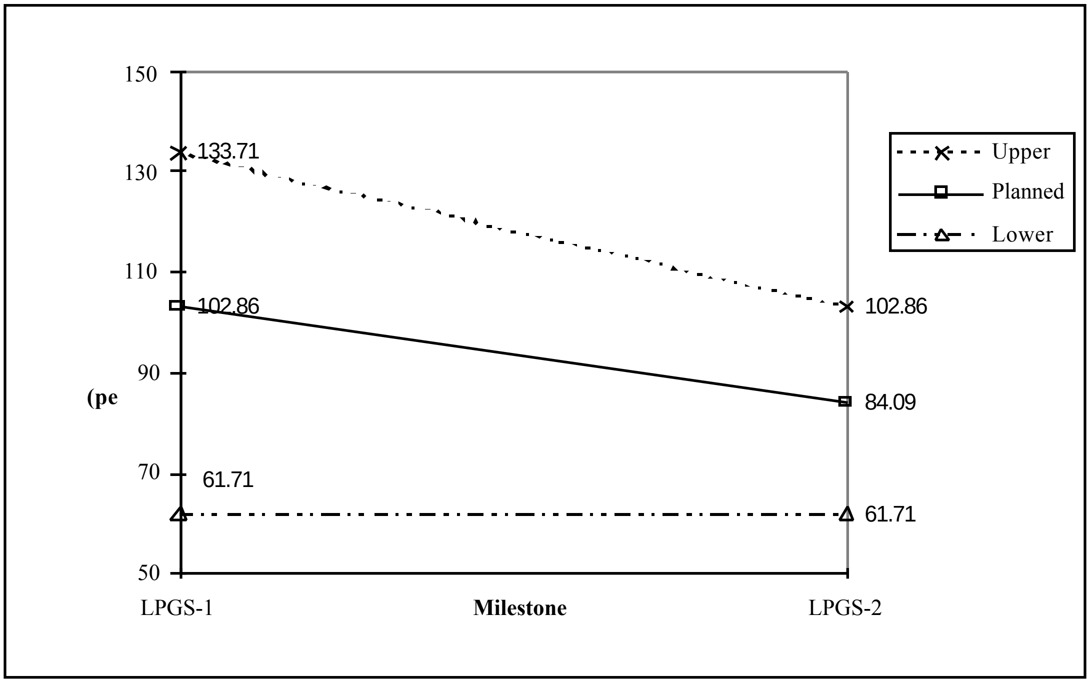

Figure 3-3. CPU Time TPM (For One WRS Scene)

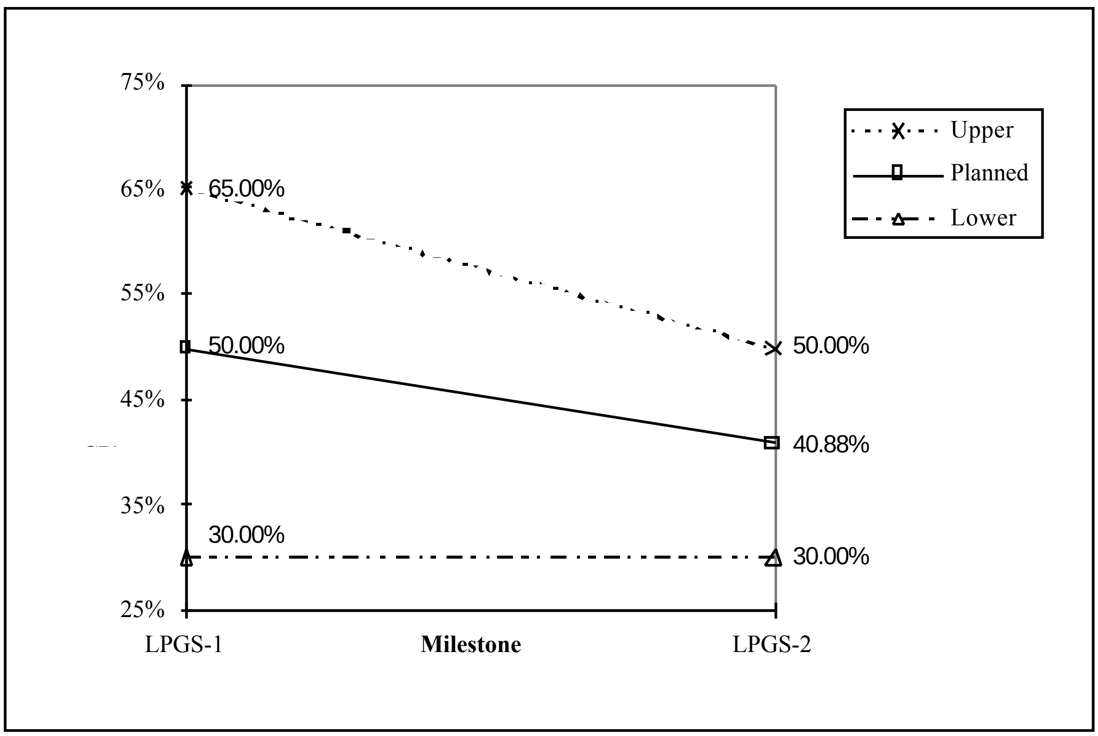

Figure 3-4. CPU Utilization TPM (28 WRS Scenes)

For radiometric processing, no benchmark data are available yet. The CPU time is estimated based on the instruction counts and the number of CPU cycles estimated for the average instructions from the performance model. This area needs special attention because of potential error in estimation. The planned values for the CPU time for radiometric processing and geometric processing for one WRS scene at various milestones are shown in Figure 3-5.

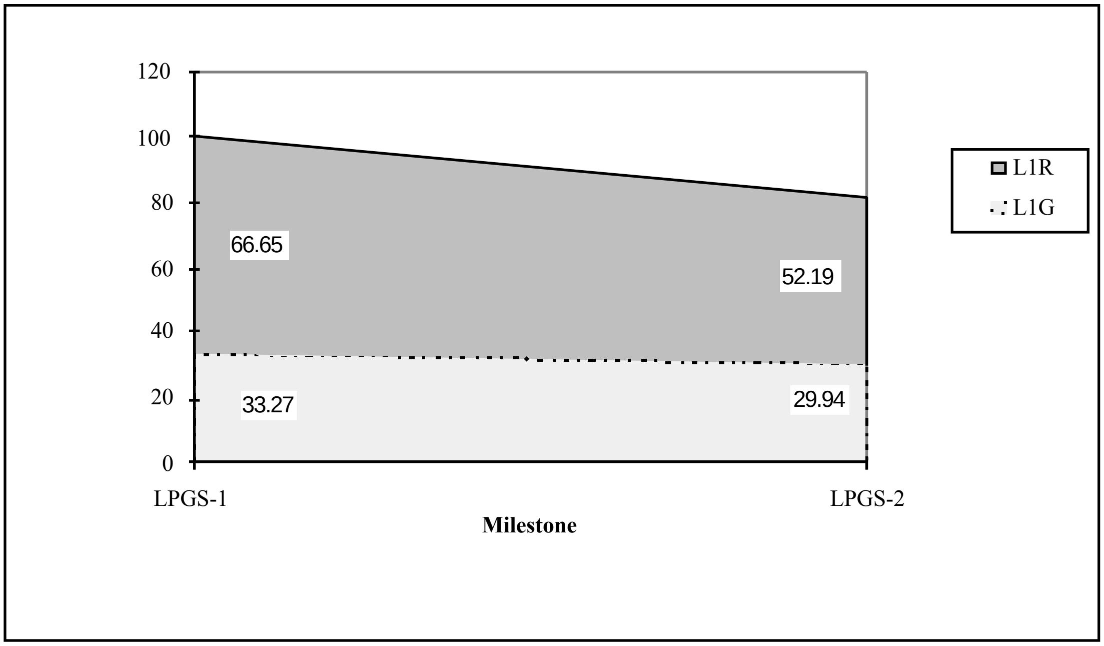

Figure 3-5. Planned CPU Time for L1R and L1G Processing

3.2.1.3 Disk I/O

Disk I/O is another critical technical performance parameter because of the large volume of data to be processed. Excessive file retrievals and saves may result in a high disk I/O utilization.

No test data are available yet. Therefore, data from the performance model will be used as the planned value for disk I/O. The redundant arrays of inexpensive disks (RAID) is the main storage for the LPGS. The disk I/O is estimated based on the volume of data being transferred at each major step of the process flow. The time it takes (5.42 minutes) to transfer this estimated volume of data is considered as the planned value for the end product. The initial planned value is assumed to be 1.5 times this value. The upper tolerance band is assumed to be 2.5 times of this value initially and 1.5 times this value at the completion of LPGS Release 2.

Figure 3-6 shows the TPM for the disk I/O time for processing one WRS scene at various milestones. The corresponding disk I/O utilization for a daily workload of processing 28 WRS scenes is shown in Figure 3-7.

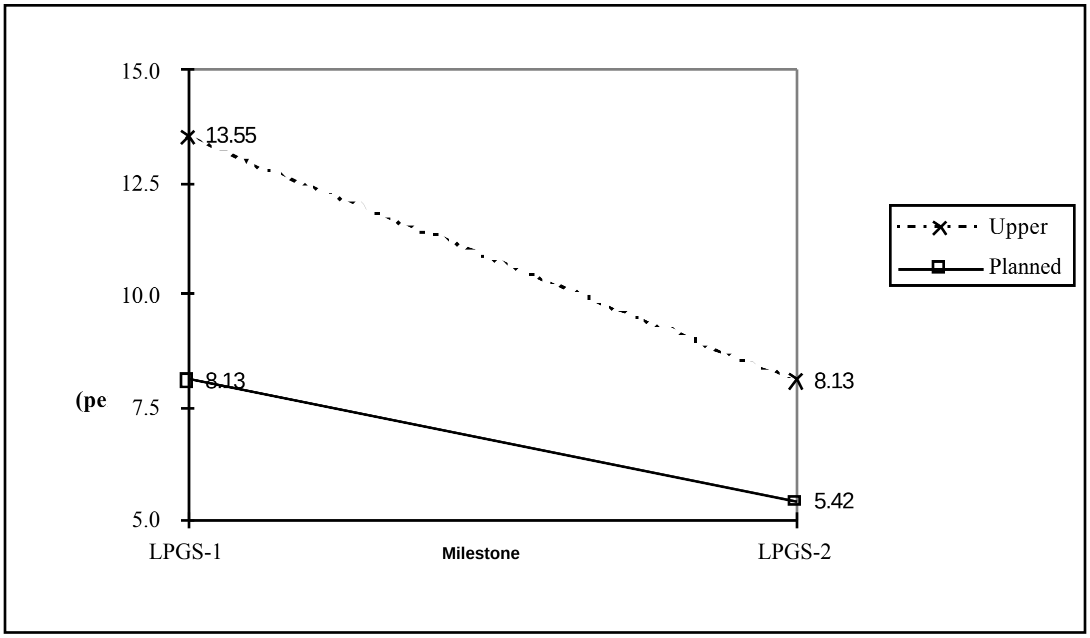

Figure 3-6. Disk I/O Time TPM (For One WRS Scene)

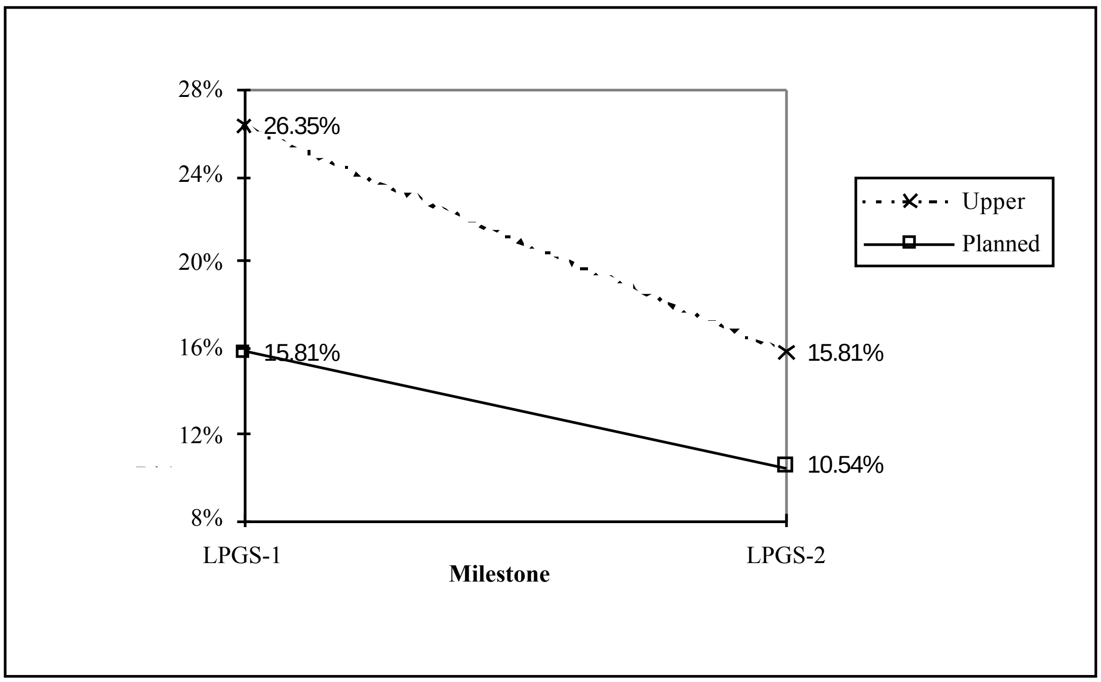

Figure 3-7. Disk I/O Utilization (28 WRS Scenes)

3.2.1.4 FDDI

During the nominal processing, the only products to be transferred across the FDDI are the L0R products from ECS and the L1 products to ECS. The FDDI bandwidth utilization is expected to be very low. Therefore, it is not necessary to establish the planned profile and tolerance bands at this time. The FDDI data transfer time will be measured and analyzed during testing.

3.2.1.5 Memory Usage

Another critical technical performance parameter is the amount of random access memory (RAM) needed to process data. For the nominal processing, the estimated memory requirement (without overhead) obtained from the performance model for processing a three-scene product request will be used as the planned value for the end product. It is assumed that an additional 20 percent will be needed initially. The upper tolerance band is set to be 1.2 times the initial planned value initially and 1.1 times the final planned value at the completion of the LPGS Release 2. The memory usage will be measured for processing one single band of data with one CPU. For the geometric processing, memory usage will also be measured for processing one single band of data with multiple CPUs. With multiple CPUs, the total memory required should not increase significantly from the memory required with one CPU. Figure 3-8 shows the TPM for the memory usage for radiometric processing and geometric processing of one band (Band 1-5 or 7) of data. The memory usage shown in this figure does not include the memory required for

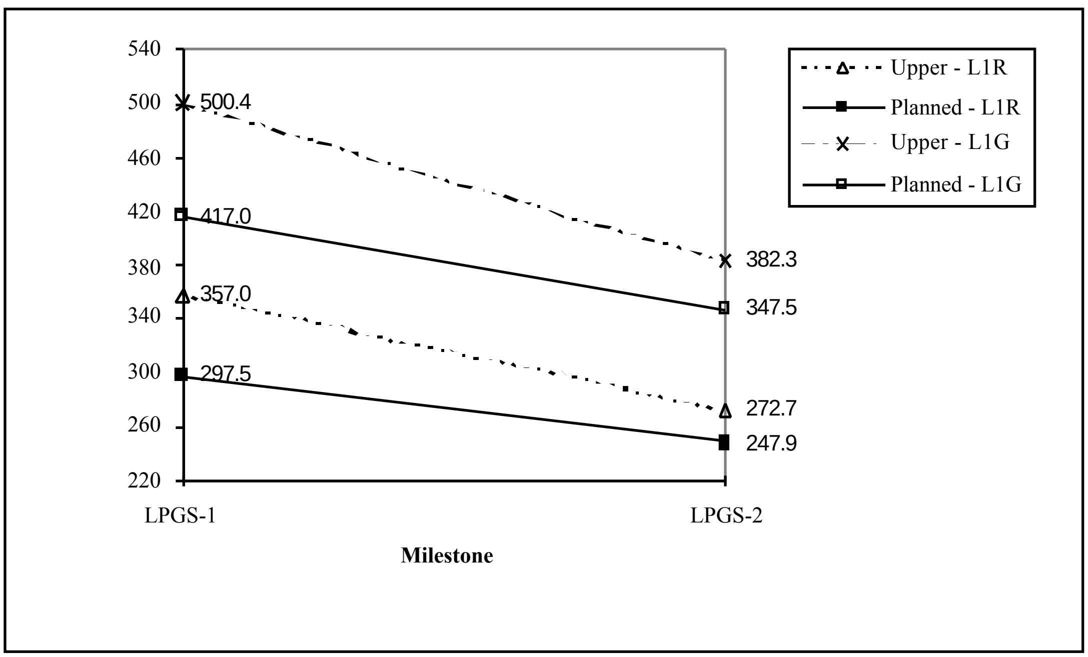

Figure 3-8. Memory Usage for Processing Band 1-5 or 7 Data (for three scenes)

the operating system and programs. The memory usage for processing Band 8 data will be four times of memory needed for Band 1-5 or 7.

3.2.1.6 Elapsed (Wall Clock) Time

The elapsed or wall clock time for a job varies significantly depending on what other jobs are running on the system. To obtain a reasonable and meaningful elapsed time for a job, nothing else other than this job should be running on the system. Assuming nothing else is running, Figure 3-9 shows the TPM of the elapsed time for processing one WRS scene of data. The planned profile and the upper tolerance band for the elapsed time are derived from the corresponding CPU time, disk I/O time, and FDDI data transfer time. Two configurations are considered in the figure, 1 CPU and 4 CPUs. To be consistent with the current LPGS software design, for a 4-CPU configuration, it is assumed that parallel processing within a band can only be performed for the geometric processing and that sequential processing of all bands is required for the radiometric processing.

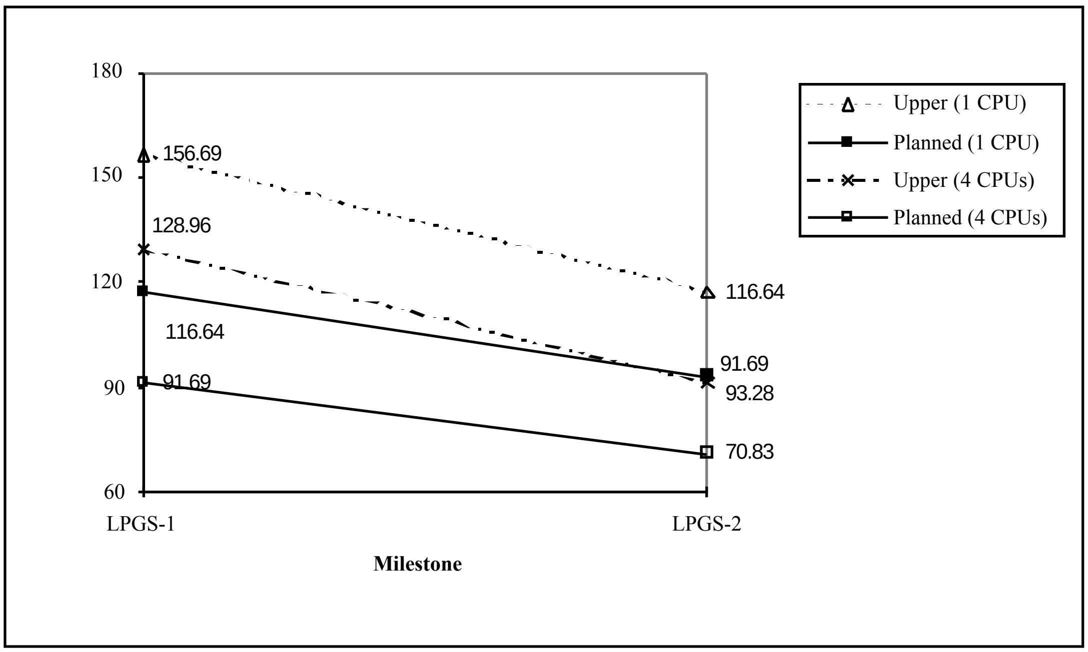

Figure 3-9. Elapsed Time for Processing One WRS Scene of Data

3.2.2 Non-Nominal Processing

The non-nominal processing assumes processing of up to three different work orders: benchmark work order, diagnostic processing work order, and reprocessing work order. The non-nominal processing requires extensive visual quality assessment performed by the analysts. Except for the visual quality assessment, benchmark, diagnostic, and reprocessing each requires resources at the same levels as the L1R processing, L1G processing, and product formatting portions of the nominal processing, and each involves the same resources as the nominal processing. Therefore, the same measurements discussed in Section 3.2.1 for the nominal processing also apply to the non-nominal processing. No separate profiles and tolerance bands will be established for the non-nominal processing. However the visual quality assessment will be performed on the QA/AA

HWCI workstation and will require transfer of a significant amount of data through the FDDI. Measurements related to the visual quality assessment will be discussed in the next section.

3.2.3 Visual Quality Assessment

The visual quality assessment is to be performed on the QA/AA HWCI workstation. It provides the capability for the analyst to assess visually the quality of the images and requires transfer of data from the RAID of the L1 processing HWCI to the workstation through the FDDI. The visual quality assessment is highly interactive. Depending on the extent of analysis to be performed, the amount of data to be transferred and the resources needed to support visual analysis vary significantly. Therefore the measurements will be taken on the per-band basis.

The resources needed include the RAID and FDDI of the L1 processing HWCI and the CPU and memory of the QA/AA HWCI. Parameters related to the RAID and FDDI are of prime interest because of their effects on the overall system performance. Parameters related to the CPU and memory are not critical because they are local to the workstation, which is dedicated to quality analysis only.

3.2.3.1 CPU Time

The 02 workstation is primarily used for visual assessment. The CPU time it takes to display an image is not expected to be a concern compared to the amount of time the analyst will spend analyzing the image. Therefore, it is not necessary to establish the planned profile and tolerance bands at this time. The CPU time will be measured and analyzed during testing.

3.2.3.2 Disk (RAID) I/O

To perform visual quality assessment on the QA/AA workstation, the image needs to be transferred from the RAID of the L1 processing HWCI to the workstation. The disk I/O time it takes to transfer one band (Band 1-5 or 7) of data is about 2 seconds and is not expected to be a concern. Therefore, it is not necessary to establish the planned profile and tolerance bands at this time. The disk I/O time will be measured and analyzed during testing.

3.2.3.3 FDDI

During the nominal processing, the only products to be transferred across the FDDI are the L0R products from ECS and the L1 products to ECS. The FDDI bandwidth utilization is expected to be very low. The QA/AA workstations are connected to the Origin 2000 in the L1 processing HWCI through the FDDI. To perform visual quality assessment on the QA/AA workstation, the FDDI bandwidth utilization will be significantly increased as the result of transferring data from the L1 processing HWCI to the workstations. The amount of increase depends on the number of images to be analyzed on the QA/AA workstation.

For visual quality assessment on the QA/AA workstation, the TPM for the FDDI data transfer time for one scene is shown in Figure 3-10. Data from the performance model are used as the planned value for the end product. The initial planned value is assumed to be 1.5 times this value. The initial and final values of the upper tolerance band are 1.5 times the initial planned value and

1.25 times the final planned value, respectively. The FDDI data transfer time for Band 8 data will be four times the transfer time for Band 1-5 or 7. Because of differences in file size, separate parameter values are used for the L1R and L1G images.

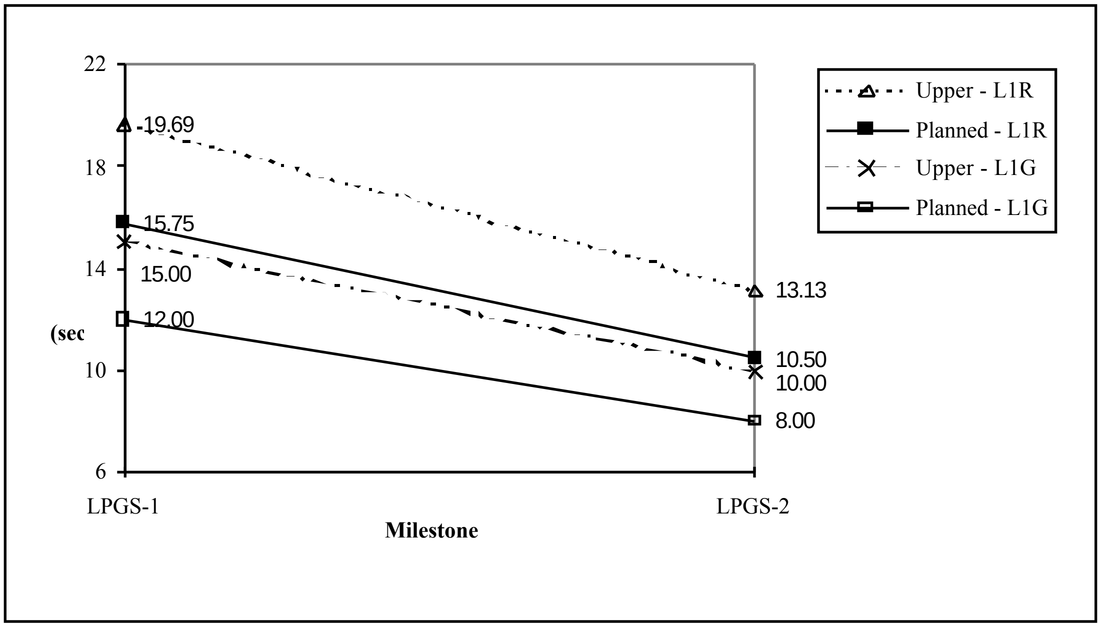

Figure 3-10. FDDI Data Transfer Time for Transferring One Band (Band 1-5 or 7) of Image to Workstation

3.2.3.4 Memory

COTS software packages such as ENVI, IDL, Oracle, and FrameMaker will be used as tools for visual quality assessment. The memory usage on the workstation will be measured and analyzed during testing. The planned parameter profile and tolerance bands, however, are not to be established at this time.

3.3 Determine Corrective Actions

If the current or projected value of a TPM parameter falls outside the tolerance bands, an assessment of the potential causes will be made. Trends in values will be examined to determine whether the problem is newly introduced or is the result of ongoing processes. If the out-of-tolerance condition is the result of potential system performance issues, a corrective action plan will be developed. The variances are analyzed to determine the cause and to assess the impacts. Alternative recovery plans will be developed and will show fully explored cost, schedule, and technical performance implications. Where performance exceeds requirements, opportunities for reallocation of requirements and resources will be assessed.

3.4 Reporting TPM Results

The TPM reporting will directly support mitigation of technical risks. It includes a graphical representation of the technical performance parameter profile versus actual measured values, brief analysis, and any necessary corrective actions. The TPM performance is correlated with development cycle milestones or major assessment events.

The following information will be included in the TPM report:

- Date—Date report was generated.
- System requirement—Requirement number and description for which critical parameter is being tracked.
- Parameter measured—Brief description of critical system parameter that is being tracked.
- Performance comparison—A comparison, preferably in graphical form, of planned versus actual parameter value achievement over time. Figure will identify required parameter value; upper and lower tolerance bands; planned value achievement; actual values obtained through analysis, modeling, and testing; and a new estimated final value based on actual values and changes that can be attained within the remaining cost and schedule baselines. All major TPM milestones and events at which assessments are made will be identified.
- Measurement method—Brief description of method used to assess parameter at this milestone or event.
- Status—Brief description of current system configuration (and any changes that have occurred since the last report), discussion of tests performed, analysis that supports obtained value and new estimated final value, and/or any other information relevant to the tracking of this parameter.
- Variance assessment—Description of the cause of the variance (if any) and its impact on other TPM parameters and on the overall system.
- Recommended action—Recommendation to resolve or correct variance that exceeds tolerance thresholds.

The TPM results will be reviewed during the LPGS/IAS Project Control Management Board meetings and major program milestones of the development cycles.

3.5 Milestones and Schedules

The results of actual tests of as-built system components, subsystems, and complete systems will be used when they are available. Before the complete test results are available for the end product, the new current estimate for the end product will be derived based on the partially available actual values. This section summarizes the milestones for collecting the measurements during the development cycle.

Table 3-4 shows the major functions and the extent that can be tested at each of the three major milestones.

Table 3-4. Functions at Major Milestones

Function	IAS Release 2	LPGS Release 1	LPGS Release 2
Ingest data	Preliminary[1]	Updated for LPGS[2] (complete)	Complete
L1R process	Preliminary	Updated for LPGS (complete)	Complete
L1G process	Preliminary	Updated for LPGS (complete)	Complete
Format product		Partial	Complete
Transfer product		Partial	Complete
Quality assessment		Partial	Complete

[1] Preliminary—Functions required for the LPGS are available in IAS release and can be tested with IAS release (subject to resource availability).

[2] Updated for LPGS—Reuse of software from the IAS with or without modifications and requiring retest in the LPGS environment.

Based on the functions available at each milestone, Table 3-5 shows the parameters that can be measured at each of the three major milestones.

At earlier milestones, parameter values will be measured from a single band and extrapolated for the entire scene. Upon completion of the LPGS Release 2, parameter values will be measured from processing 28 scenes for a required daily workload. Table 3-6 shows the number of bands/scenes to be used at each of the three milestones.

Table 3-5. Parameters To Be Measured at Major Milestones

Function	IAS Release 2	LPGS Release 1	LPGS Release 2
Data processing			
CPU time	Preliminary[1]	Partial[3]	Complete[4]
Disk I/O	Preliminary	Partial	Complete
FDDI data transfer	Preliminary	Partial	Complete
Memory usage	Preliminary	Partial	Complete
Elapsed time	Preliminary	Partial	Complete
Visual assessment			
CPU time	Preliminary	Partial	Complete
Disk (RAID) I/O	Preliminary	Partial	Complete
FDDI data transfer	Preliminary (partial)[2]	Partial	Complete
Memory usage	Preliminary	Partial	Complete

[1] Preliminary—Preliminary measurements can be obtained from IAS release (subject to resource availability).

[2] Preliminary (partial)—Parameter values can be partially obtained from IAS release (not all values can be measured) (subject to resource availability).

[3] Partial—Parameter values can be partially obtained from LPGS release.

[4] Complete—All measurements can be obtained from LPGS release.

Table 3-6. Number of Bands/Scenes Used for Measurements

	IAS Release 2	LPGS Release 1	LPGS Release 2
Band/scene to be used	One scene, all bands	One scene, all bands	28 scenes (including reprocessing), all bands

Abbreviations and Acronyms

AA	anomaly analysis
CPF	calibration parameter file
CPU	central processing unit
DAAC	Distributed Active Archive Center
ECS	EOSDIS Core System
EDC	EROS Data Center
EGS	EOS Ground System
ENVI	Environment for Visualizing Images
EOS	Earth Observing System
EOSDIS	EOS Data and Information System
EROS	Earth Resources Observation System
ESDIS	Earth Science Data and Information System
ETM+	enhanced thematic mapper plus
F&PRS	functional and performance requirements specification
FAST	Fast Argonne System for Transport
FDDI	fiber-optic data distribution interface
FIFO	first in-first out
GB	gigabyte
GeoTIFF	geographic tag(ged) image file format
GPS	geometric processing subsystem
HDF	hierarchical data format
HWCI	hardware configuration item
I/O	input/output
IAS	Image Assessment System
IC	internal calibrator
IDL	Interactive Data Language

L0R	Level 0R product
L1	Level 1
L1G	Level 1 geometrically corrected
L1R	Level 1 radiometrically corrected
LAN	local area network
LPGS	Level 1 Product Generation System
MB	megabyte
mm	millimeter
MSCD	mirror scan correction data
MTTR	mean time to restore
PCD	payload correction data
QA	quality assessment
RAID	redundant arrays of inexpensive disks
RAM	random access memory
RPS	radiometric processing subsystem
SCSI	small computer systems interface
SGI	Silicon Graphics, Inc.
TBD	to be determined
TPM	Technical Performance Measurement
WRS	Worldwide Reference System